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(54) **Textile structures containing linear low density poly-ethylene binder fibers**

(57) A fiber comprising at least about 80% by weight linear low density polyethylene and having a melting point less than 109°C is disclosed. Also disclosed are thermally consolidated fiber structures comprising (1) at least about 3% by weight, based on the total weight of the structure, of lower melting binder fibers comprising at least 80% by weight linear low density polyethylene, preferably having a melting point less than 109°C, and (2) not more than 97% by weight, based on the total weight of the structure, of nonmelting fibers, or fibers having a melting point higher than the linear low density polyethylene fibers. The fiber structures can be in the form of multi filament yarns, woven or nonwoven textile fabrics, carpets, or laminates.

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Description

This invention relates to polyethylene fibers and to textile structures comprising a higher melting fiber and a lower melting binder fiber.

Textile structures are produced from a variety of materials both natural and manmade. Numerous processes are used in the production of these structures, for example, spinning, weaving, knitting, tufting, carding, and needlepunching. The structures thus produced can be dimensionally unstable. Several techniques are used to stabilize these structures, for example, latex treatment or lamination. Some of these treatments require solvents or chemicals with an undesirable environmental impact. Another technique is the blending of nonadhesive fibers with potentially adhesive binder fibers to form a yam or other textile structure, then activating the potentially adhesive fibers to bond them to the other fibers. The use of binder fibers in stabilizing nonwoven materials is described in U.S. Patent Nos. 2,277,049 and 2,464,301. Twisted yams made with binder fibers having a melting point of 110°-170°C are described in European Patent No. 324,773. Wrap staple yams containing low melting binder wrap strands based on copolyamides and copolyesters with melting points less than 149°C are described in U.S. Patent No. 4,668,552. Binder fibers made from a blend of branched low density polyethylene having a melting point of about 107°C and crystalline polypropylene are disclosed in U.S. Patent No. 4,634,739. The use of polyethylene fibers with melting points higher than 110°C, and polypropylene fibers in needled, nonwoven webs is described in U.S. Patent Nos. 5,077,874 and 5,199,141. Because of the small differential in the melting points of the two fibers, this combination of fibers in the nonwoven structure requires precise control of the heat treatment temperatures to prevent any adverse effect on the primary fibers of the structure, i.e., polypropylene fibers.

It would therefore be desirable to provide a significant differential between the melting point of the primary fibers of a textile structure and the binder fibers, providing a more forgiving process for thermal treatment in the production of dimensionally stable textile structures. This differential can be achieved by providing binder fibers with a sufficiently low melting temperature. However, prior to the instant invention, no one has been able to produce binder fibers comprising linear low density polyethylene fibers having a melting point less than 109°C.

This invention is directed to fibers comprising at least about 80% by weight linear low density polyethylene (LLDPE) having a melting point of less than 109°C. These fibers can be used in fiber structures of various kinds, which optionally contain fibers other than these LLDPE fibers.

In a preferred embodiment, LLDPE fibers can be used to prepare dimensionally stable, thermally consolidated fiber structures comprising (1) at least about 3% by weight, based on the total weight of the structure, of lower melting fibers comprising at least 80% by weight linear low density polyethylene, and (2) not greater than about 97% by weight, based on the total weight of the structure, of nonmelting fibers, or fibers having a melting point higher than the linear low density polyethylene fibers.

The fiber structures are consolidated by heating to melt the linear low density polyethylene binder fibers without melting the higher melting fibers. The fiber structures of this invention can be in the form of yams, woven or nonwoven fabrics, carpets, and laminates in which at least one layer comprises a fiber structure of this invention.

The thermally consolidated fiber structures have improved dimensional stability, abrasion resistance, and wear properties. The linear low density polyethylene binder fibers can provide a soft, flexible cloth-like fabric with good drape.

The fibers comprising at least about 80% by weight linear low density polyethylene are copolymers of ethylene and up to 20% by weight of a 3-12 carbon alpha-olefin such as, for example, propylene, butene, octene, and hexene. Alpha-olefins having 4-8 carbon atoms are preferred. Mixtures of the alpha-olefin comonomers can also be used, e.g., butene/octene or hexene/octene. The copolymers preferably comprise at least 80% ethylene. Linear low density polyethylene (LLDPE) is "linear", but with the alkyl groups of alpha-olefin comonomer pendent from the polymer chain, rather than having short chains of polymerized ethylene units pendent from the main polymer chain as is the case with low density polyethylene. The density of LLDPE is typically about 0.88 to 0.94 g/cc. The melting point of the LLDPE fibers can vary depending upon the ratio of the ethylene monomer and the comonomer, and on the polymer structure.

Suitable linear low density polyethylenes include, for example, INSITE™, ENGAGE™, and ASPUN® polyethylenes available from Dow Chemical Company, Midland, Michigan, U.S.A., which have melting points of about 90° to 130°C. The preferred fibers have melting points < 109°C. Fibers spun from linear low density polyethylenes having melting points < 109°C have not previously been available.

The linear low density polyethylene fibers can be crimped or uncrimped continuous filaments; crimped or uncrimped cut fibers, i.e., staple fibers, with lengths of about 3 to 150 millimeters (mm), preferably about 5-150 mm, and most preferably about 25-50 mm, or discrete microfibers, i.e., melt-blown fibers. The linear low density polyethylene fibers preferably have a denier of about 1-30, more preferably about 2-15, and most preferably about 2-6. In this specification the term "fibers" is meant to include all of the types of fibers and filaments described above. The fibers can contain up to about 20% by weight of other materials such as, for example, stabilizers, pigments, additives and polymers other than linear low density polyethylene (e.g., polypropylene, polystyrene, copolymers of olefins such as propylene, ethylene and butylene, etc., polyesters and polyamides).

The fibers can have a nominal amount, for example, up to about 2% by weight, of a surface finish, which can be either hydrophilic or hydrophobic. Suitable finishes include, for example, phosphate ester antistatic finishes, ethoxylated fatty acid esters, and polydimethyl siloxanes. Such finishes are described, for example in U.S.Patent No. 4,938,832 and published European patent applications 486158, 557024, and 516412, the disclosures of which are incorporated by reference.

Linear low density polyethylene (LLDPE) fibers comprising at least about 80% by weight linear low density polyethylene having a melting point less than 109°C can be used in fiber structures of various kinds, which optionally contain fibers other than the specified linear low density polyethylene fibers.

The fiber structures of this invention include yarns, for example, continuous filament, staple, wrap, or novelty yarns; woven or knitted textile fabrics; tufted textile fabrics such as velvet; loop pile or cut pile carpets; nonwoven fabrics or structures, for example, needlepunched or hydroentangled nonwovens; and laminates comprising several layers of the textile structures of this invention, or laminates comprising at least one layer of a textile structure of this invention and at least one layer of another textile structure.

In a preferred embodiment, LLDPE fibers are used in a thermally consolidated fiber structure comprising (1) at least about 3% by weight, based on the total weight of the structure, of lower melting fibers comprising at least about 80% by weight linear low density polyethylene, and (2) not greater than about 97% by weight, based on the total weight of the structure, of nonmelting fibers or fibers having a melting point higher than the linear low density polyethylene fibers. Typically the structures contain less than 50% by weight LLDPE fibers. A preferred range of LLDPE fibers is about 5 to about 20 weight %.

The second, higher melting fibers in the thermally consolidated structures of this invention can be any fiber that melts at least 10°C higher than the linear low density polyethylene fibers, preferably at least 20°C higher, and most preferably at least 30°C higher. When linear low density polyethylene fibers having a melting point <109°C are used with polypropylene fibers, the difference between the melting points of the two fibers can be >50°C. These fibers can be crimped or uncrimped continuous filaments; crimped or uncrimped cut fibers, or discrete microfibers. Such fibers include, for example, polypropylene, polyamide, and polyester fibers. Polypropylene fibers are preferred. Nonmelting fibers can also be used. Such fibers include, for example, cotton, wool, acrylic, and rayon fibers. These fibers are preferably used in a range of about 80% to about 95% by weight.

After the linear low density binder fibers and the higher melting fibers are combined, the binder fibers are melted by heating to bond the higher melting fibers to each other. After cooling, the polyethylene solidifies and locks the higher melting fibers in place, producing a dimensionally stable structure.

The linear low density polyethylene multifilament yarns and staple fibers with a melting point of about 107°C used in the following examples were prepared using ENGAGE™ resin designated 58200.03 available from The Dow Chemical Company, Midland, Michigan, U.S.A. (Dow). The linear low density polyethylene multifilament yarns and staple fibers with a melting point of about 128°C in the examples were prepared using ASPUN™ resin designated 6835 available from Dow. These resins were melt extruded using a multi-hole spinnerette at temperatures of about 200° to 230°C (normally spinning is carried out at 170-250°C) and the extruded fibers were taken up on packages. These fibers were further drawn about 2 to 4 times to obtain the final denier per filament. The staple fibers were crimped and cut.

The polyethylene 300 denier/52 filament continuous filament yarns used in the following examples had less than 2% of the surface finish TRYLUBE 7640A, available from Henkel Corporation, Ambler, PA, U.S.A. The polyethylene staple fibers had less than 2% of the surface finish LUROL PP912, available from George A. Goulston Co., Monroe, NC, U.S.A.

In this specification, all percentages are by weight unless otherwise noted.

Example 1

Polypropylene (PP) bulked continuous multifilament yarns were co-mingled with linear low density polyethylene (LLDPE) continuous multifilament yarns to produce polypropylene/polyethylene composite yarns as shown in Table 1. The composite yarns were then heat-treated at the temperatures indicated in Table 1 for five minutes. Physical characteristics of the heat-treated yarns are also shown in this table. Dimensionally stable yarns with good bonding between the polypropylene filaments were obtained.

Table 1

Sample No.	Polypropylene Yarn (PP)	Polyethylene Yarn (LLDPE)	PE/LLDPE Ratio (%/%)	Heat Treatment Temperature (°C)	Heat-Treated Composite Yarn Characteristics
A	1 End of 500 denier/144 filaments M.P. ≈ 162°C	1 End of 300 denier/52 filaments M.P. ≈ 107°C	62/38	120°C	Soft, and good bonding between fibers.
B	2 Ends of 500 denier/144 filaments M.P. ≈ 162°C	1 End of 300 denier/52 filaments M.P. ≈ 107°C	77/23	120°C	Soft, and good bonding between fibers.
C	1 End of 500 denier/144 filaments M.P. ≈ 162°C	1 End of 300 denier/52 filaments M.P. ≈ 128°C	62/38	135°C	Hard, and good bonding between fibers.

Example 2

Polyester (PET) bulked continuous multifilament yarns were twisted with linear low density polyethylene (LLDPE) continuous multifilament yarns to produce polyester/polyethylene composite yarns as shown in Table 2. These twisted yarns were then heat-treated at the temperatures indicated in Table 2 for five minutes. Physical characteristics of the heat-treated yarns are also shown in this table. Dimensionally twist-stable yarns with good bonding between the polyester filaments were obtained.

Table 2

Sample No.	Polyester Yarn (PET)	Polyethylene Yarn (LLDPE)	PET/LLDPE Ratio (%/%)	Heat Treatment Temperature (°C)	Heat-Treated Composite Yarn Characteristics
D	2 Ends of 400 denier/94 filaments M.P. ≈ 260°C	1 End of 300 denier/52 filaments M.P. ≈ 128°C	73/27	135°C	Soft, and good bonding between fibers.
E	4 Ends of 400 denier/94 filaments M.P. ≈ 260°C	1 End of 300 denier/52 filaments M.P. ≈ 128°C	84/16	135°C	Soft, and good bonding between fibers.
F	1 End of 400 denier/94 filaments M.P. ≈ 260°C	1 End of 300 denier/52 filaments M.P. ≈ 128°C	57/43	135°C	Soft, and good bonding between fibers.

Example 3

Woven fabrics were prepared using different warp and filling yarns as shown in Table 3. LLDPE is linear low density polyethylene. These woven fabrics were then heat-treated at the temperatures indicated in Table 3 for 5 minutes. Physical characteristics of the heat-treated fabrics are also indicated in this table. Dimensionally stable fabrics with good bonding between fibers were obtained. In the table, den. = denier, fil. = filaments.

Table 3

Sample No.	Warp Yarn	Filling Yarn	M.P. of LLDPE (%)	LLDPE (%)	Heat Treatment Temp. (°C)	Heat-Treated Fabric Characteristics
G	Polyester, 500 denier staple spun yarn M.P. ≈ 260°C	Alternate Ends of 300 den./52 filaments LLDPE; 400 den./92 fil. polyester	128	21	135	Soft, and good bonding between fibers.
H	Polyester, 500 denier staple spun yarn M.P. ≈ 260°C	Alternate Ends of 300 den./52 filaments LLDPE; 400 den./92 fil. polyester	107	21	120	Soft, and good bonding between fibers.
I	Polyester, 500 denier staple spun yarn M.P. ≈ 260°C	Alternate Ends of 300 den./52 filaments LLDPE; 500 den./144 fil. polypropylene M.P. ≈ 162°C	107	21	120	Soft, and good bonding between fibers.

Example 4

A nonwoven web with a basis weight of 62 g/yd^2 was prepared using a 50%/50% by weight blend of linear low density polyethylene 3 denier/filament staple fibers with a melting point of about 107°C and polypropylene 2.2 denier/filament staple fibers with a melting point of about 162°C. This nonwoven web was needlepunched to a 95 g/yd^2 woven polyester fabric with a melting point of about 260°C. Two samples of this fabric structure were each heat-treated for five minutes at 118°C and then at 123°C. These heat-treated fabric structures exhibited good dimensional stability and soft hand.

Example 5

A nonwoven web having a basis weight of 53 g/yd^2 was prepared using a 25%/75% by weight blend of linear low density polyethylene 3 denier/filament staple fibers with a melting point of about 107°C and polypropylene 2.2 denier/filament staple fibers with a melting point of about 162°C. Laminates comprising two, four, and six layers of this nonwoven web were prepared and were each heat-treated at 120°C for 5 minutes. These heat-treated nonwoven structures exhibited good dimensional stability and soft hand.

Example 6

A nonwoven web having a basis weight of 62 g/yd^2 was prepared using a 50%/50% by weight blend of linear low density polyethylene 3 denier/filament staple fibers with a melting point of about 107°C, and polypropylene 2.2 denier/filament staple fibers with a melting point of about 162°C. This nonwoven web was combined with a plain weave woven polyester fabric having a basis weight of 95 g/yd^2, and the two structures were needlepunched together. This composite textile structure was then heat-treated at 120°C for 5 minutes to substantially melt the linear low density polyethylene fibers. The resultant textile structure exhibited good dimensional stability and soft hand.

Example 7

A nonwoven web having a basis weight of 27 g/yd^2 was prepared using linear low density polyethylene 5 denier/filament staple fibers with a melting point of about 107°C. This nonwoven web was combined with a plain weave woven polyester fabric having a basis weight of 95 g/yd^2, and the two structures were needlepunched together. This composite textile structure was then heat-treated at 120°C for 5 minutes to substantially melt the linear low density polyethylene fibers. The resultant textile structure exhibited good dimensional stability and soft hand.

Example 8

A nonwoven web having a basis weight of 48 g/yd^2 was prepared using linear low density polyethylene 5 denier/filament staple fibers with a melting point of about 107°C. This nonwoven web was combined with a plain weave woven polyester fabric having a basis weight of 95 g/yd^2, and the two structures were needlepunched together. This composite textile structure was then heat-treated at 120°C for 5 minutes to substantially melt the linear low density polyethylene fibers. The resultant textile structure exhibited good dimensional stability and soft hand.

Use of LLDPE provides fibers that are well suited for making fiber structures, particularly with higher melting fibors of another polymer such as polypropylene, polyamide or polyester, or natural fibers. The fibers comprising LLDPE having a melting point less than 109°C of this invention provide softer structures than those made with higher melting LLDPE. In addition, they enable the practioner to make structures at lower temperatures thereby reducing possible damage to the primary fibers.

Claims

1. A fiber comprising at least about 80% by weight linear low density polyethylene having a melting point less than 109°C.

2. A fiber structure comprising fibers as claimed in claim 1.

3. A fiber structure comprising (1) fibers as claimed in claim 1, and (2) fibers other than the linear low density polyethylene fibers (1).

4. The structure of claim 2 or 3 in the form of a multifilament yarn, woven textile fabric, knitted textile fabric, tufted textile fabric, nonwoven textile fabric, or carpet.

5. A laminate comprising at least one layer of the structure of claim 4, wherein the structure is a nonwoven fabric.

6. A thermally consolidated fiber structure comprising (1) at least about 3% by weight, based on the total weight of the structure, of lower melting fibers comprising at least about 80% by weight linear low density polyethylene, and (2) not greater than about 97% by weight, based on the total weight of the structure, of nonmelting fibers or fibers having a melting point higher than the linear low density polyethylene fibers.

7. A thermally consolidated structure as claimed in claim 6 wherein the linear low density polyethylene has a melting point less than 109°C.

8. The structure of claim 6 or 7, wherein the difference in melting points between fiber (1) and fiber (2) is at least 10°C.

9. The structure of claim 8, wherein the difference in melting points between fiber (1) and fiber (2) is at least 30°C.

10. The structure of claim 9, wherein the difference in melting points between fiber (1) and fiber (2) is at least 50°C.

11. The invention of any of the preceding claims wherein the linear low density polyethylene is a copolymer of ethylene and at least one 3 to 12 carbon alpha-olefin and has a density of about 0.88 to about 0.94 g/cc.

12. The invention of claim 11 wherein the alpha-olefin is selected from the group consisting of propylene, butene, octene, hexene, and mixtures thereof.

13. The invention of claims 11 or 12 wherein the copolymer comprises at least 80% ethylene.

14. The structure of claims 6-13 wherein fiber (2) is selected from the group consisting of propylene, rayon, cotton, acrylic and wool fibers.

15. The structure of claims 6-13 wherein fiber (2) is a polypropylene, polyester or polyamide fiber.

16. The invention of any of the preceding claims wherein the linear low density polyethylene fibers are 1-30 denier staple fibers having a length of 3-150 mm.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 30 5497

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
P,X	WO-A-94 25648 (DOW CHEMICAL CO) * the whole document * ---	1-16	D01F6/30 D04H1/54 D02G3/40 B32B5/24
P,X	WO-A-94 25647 (DOW CHEMICAL CO) * the whole document * ---	1-16	
X Y	WO-A-94 12699 (EXXON CHEMICAL PATENTS INC) * the whole document * ---	1,2,4 3,5-16	
Y	EP-A-0 154 197 (DOW CHEMICAL CO) * the whole document * ---	6,8-16	
Y D D	WO-A-91 10768 (GATES FORMED FIBRE PRODUCTS) * the whole document * & US-A-5 199 141 & US-A-5 077 874 ---	3,6-16	
Y	DATABASE WPI Section Ch, Week 9316 Derwent Publications Ltd., London, GB; Class A17, AN 93-131608 & JP-A-05 071 060 (UNITIKA LTD) , 23 March 1993 * abstract * -----	5	TECHNICAL FIELDS SEARCHED (Int.Cl.6) D01F D04H D02G B32B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 November 1995	Tarrida Torrell, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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